LQD – Magnetic domains in amorphous $TbFe_2$ and $PrFe_2$

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Outline…

- What is LQD?
- $TbFe_2$ $PbFe_2$ Thin Films - Amorphous Ferromagnets
- Nuclear and magnetic scattering
- Data Reduction and Analysis

LQD

Small angle neutron scattering!

- Wavelength range: 1.5 -15 Å
- Scattering angle: 6-60 mrad
- Q range: 0.003 to 0.5 $Å^{-1}$
- Detector: 2D position sensitive grid

Good for: phase separation, morphology, and critical phenomena in hard and soft matter

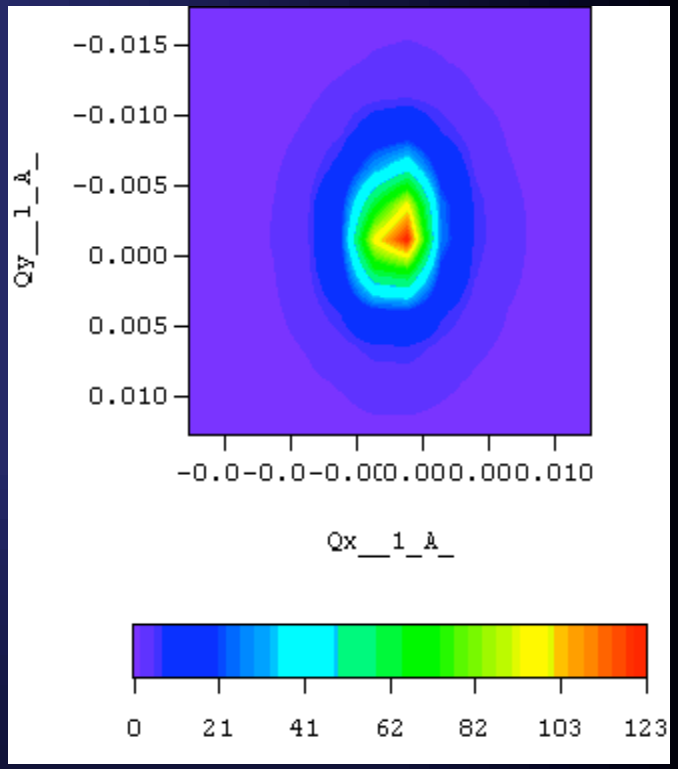
Scattering Intensity Model

$$I(Q) = \frac{A}{\left(Q^2 + \square_A^2\right)} + \frac{B}{\left(Q^2 + \square_B^2\right)^2}$$

- Lorentzian term:
  - dynamic fluctuations in the spins: magnons
- Lorentzian squared:
  - static regions of spin ordering
- $\__A$ and $\__B$ are the inverses of the corresponding correlation lengths
- Low Q approximation

Data Reduction / Analysis

- Rebin into Q and I
- Subtract nuclear scattering (above Tc) from nuclear + magnetic
- “Linearize” equation
- Fit parabola to low Q data
- Extract spin correlation length



Tb Sample Preparation

Prepared by sputtering (e-beam onto single crystal silicon)

- 1.5 microns thick
- 7 stacked samples
- Preferred axis up
- Cooled with applied B along easy axis – colinear with beam

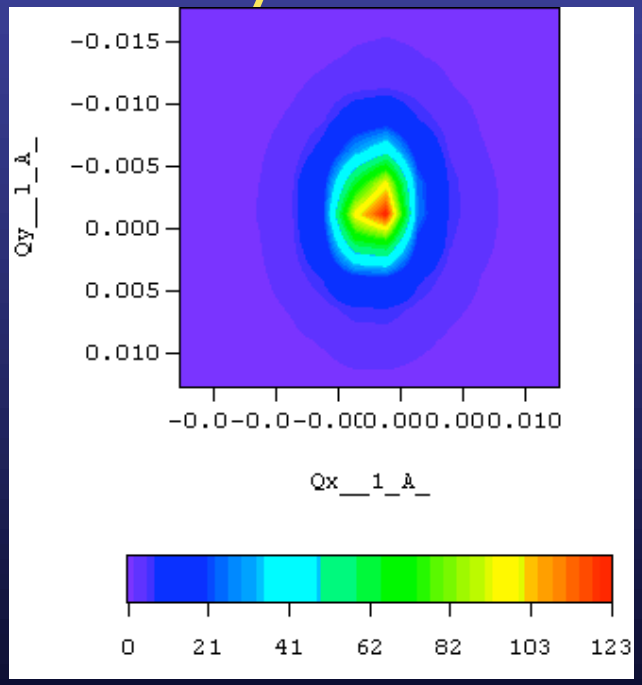
LQD Experiment 1: $TbFe_2$

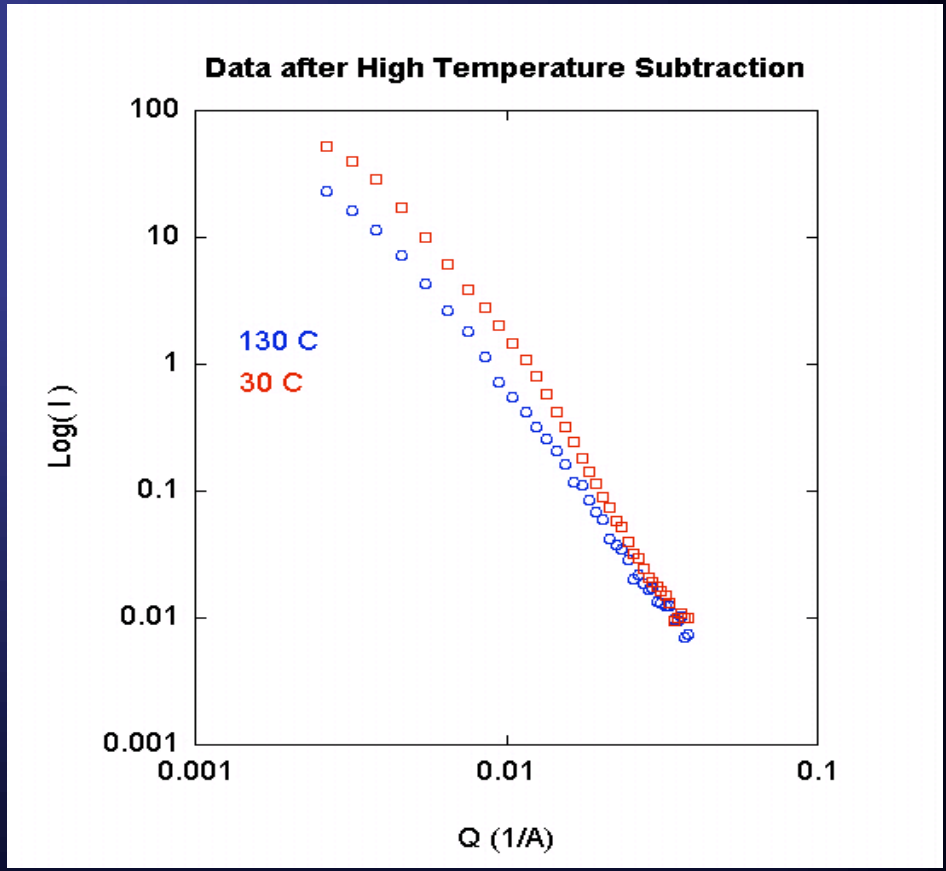
- Amorphous material
- Films grown on crystal Si
- Tc = 450 K
- Below Tc (nuclear+magnetic):
  - 300 K
  - 400 K
- Above Tc (nuclear):
  - 460 K

$TbFe_2$ Raw Data – 2D intensity

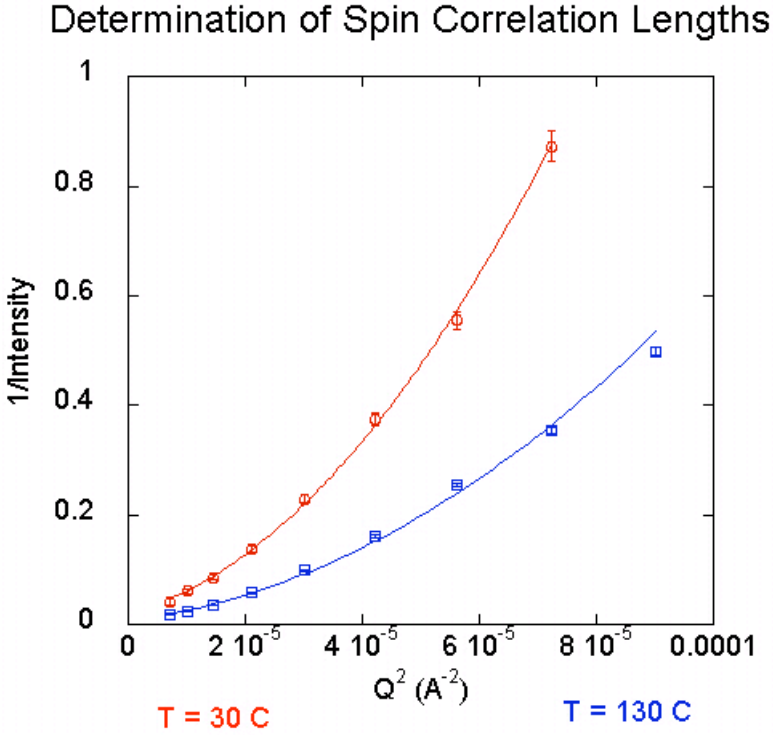
Averaged over all angles

Time averaged intensity



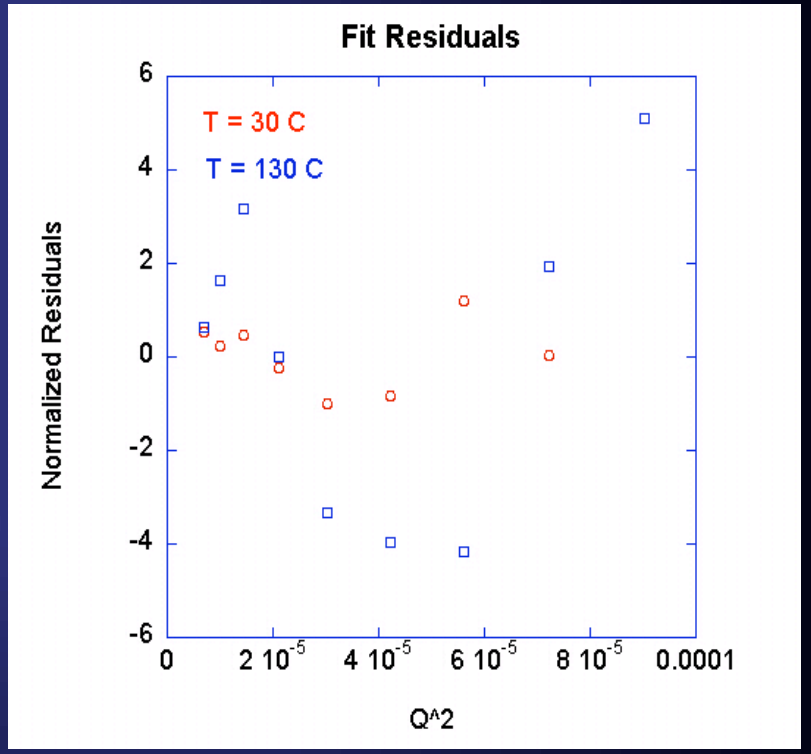


Graph from $TbFe_2$



1/I = 1/((A/(Q^2+k^ 2))^ 2)		
	Value	Error
A	9.0458e-05	1.5898e-06
k	0.0035097	0.00011076
Chisq	3.7889	NA
R	0.99922	NA

y = 1/((m1/(M0+m2^ 2))^ 2)		
	Value	Error
m1	0.00014089	9.1385e-07
m2	0.0035709	4.2968e-05
Chisq	87.213	NA
R	0.99725	NA



Note the trends in residuals, indicating a systematic error.

- Imperfections in model
- 360° binning of Q averages anisotropy

$TbFe_2$ Results

Correlation length

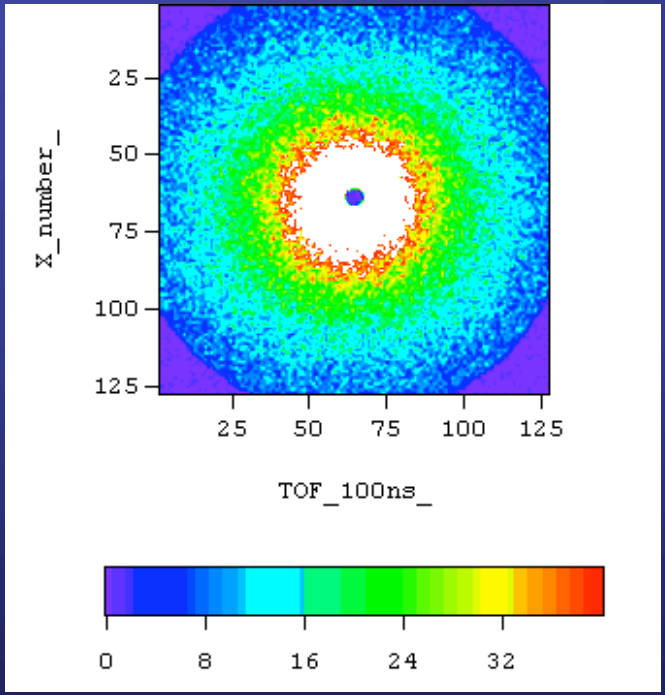
- 130°C: 280 ± 3 Å
- 30°C: 285 ± 9 Å

From F. Hellman et al., correlation lengths of 300-500 Å were found, depending on binned angle chosen.

Experiment 2: $PrFe_2$

- Amorphous material
- Films grown on crystal Cu
- Below Tc (200 K): nuclear+magnetic
- Above Tc (340K): nuclear

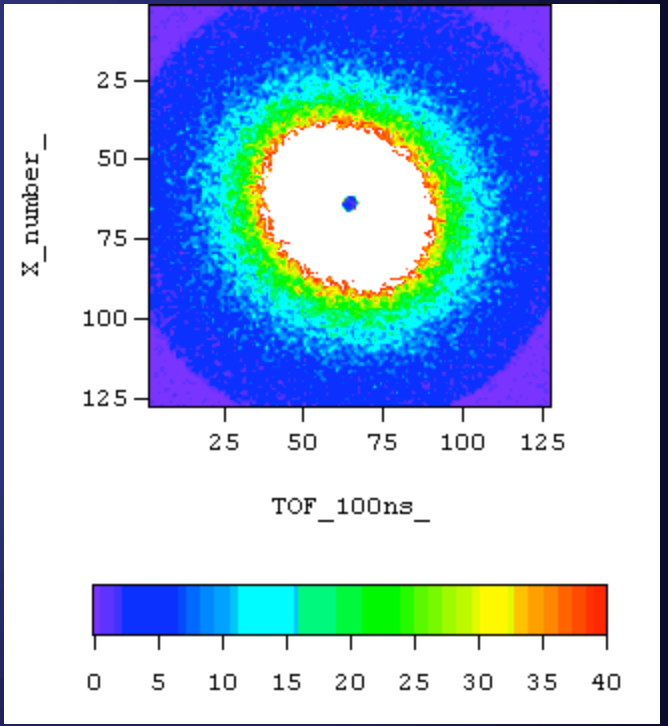
$PrFe_2$ Raw Data – 2D intensity



T = 340 K

•Above Tc

•Isotropic



T = 200 K

•Below Tc

•Anisotropic

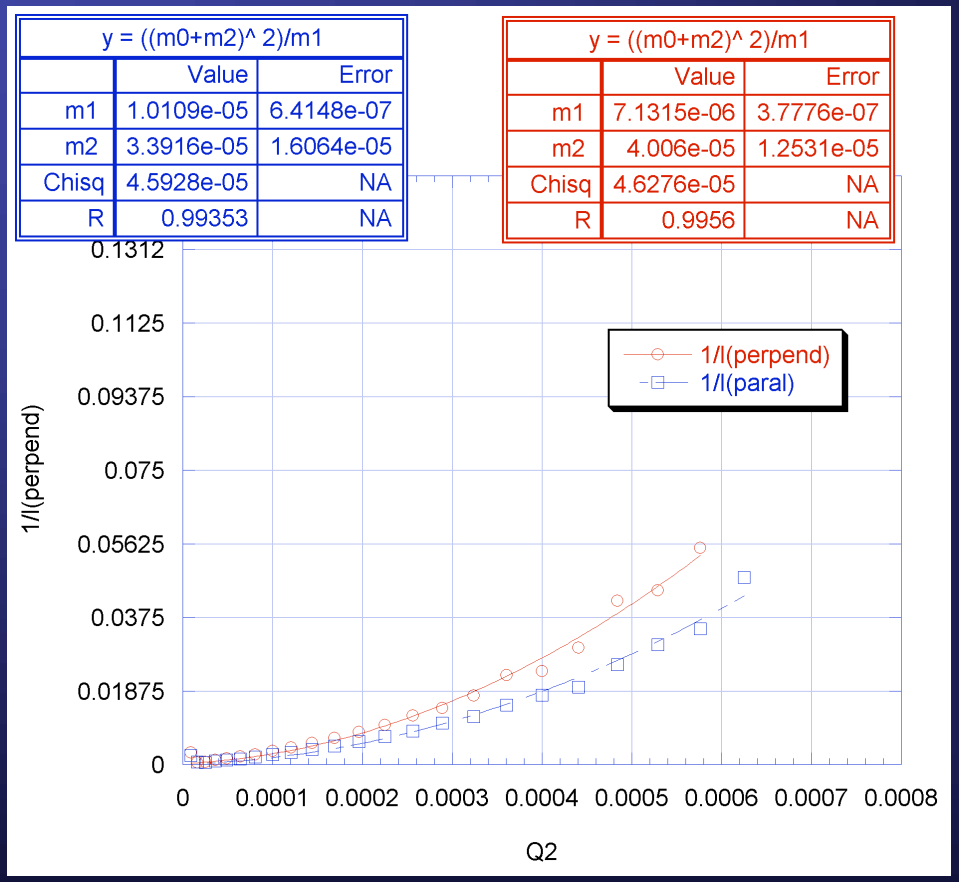
Data Analysis of $PrFe_2$

$$I(Q) = \frac{A}{(Q^2 + \square^2)^2}$$

Parallel to anisotropy direction

y = ((m0+m2)^ 2)/m1		
	Value	Error
m1	1.0109e-05	6.4148e-07
m2	3.3916e-05	1.6064e-05
Chisq	4.5928e-05	NA
R	0.99353	NA

y = ((m0+m2)^ 2)/m1		
	Value	Error
m1	7.1315e-06	3.7776e-07
m2	4.006e-05	1.2531e-05
Chisq	4.6276e-05	NA
R	0.9956	NA



Perpendicular to anisotropy direction

Spin Correlation Length (perpendicular): 158 Å

Spin Correlation Length (parallel): 172 Å

Indicative of static spin localization !